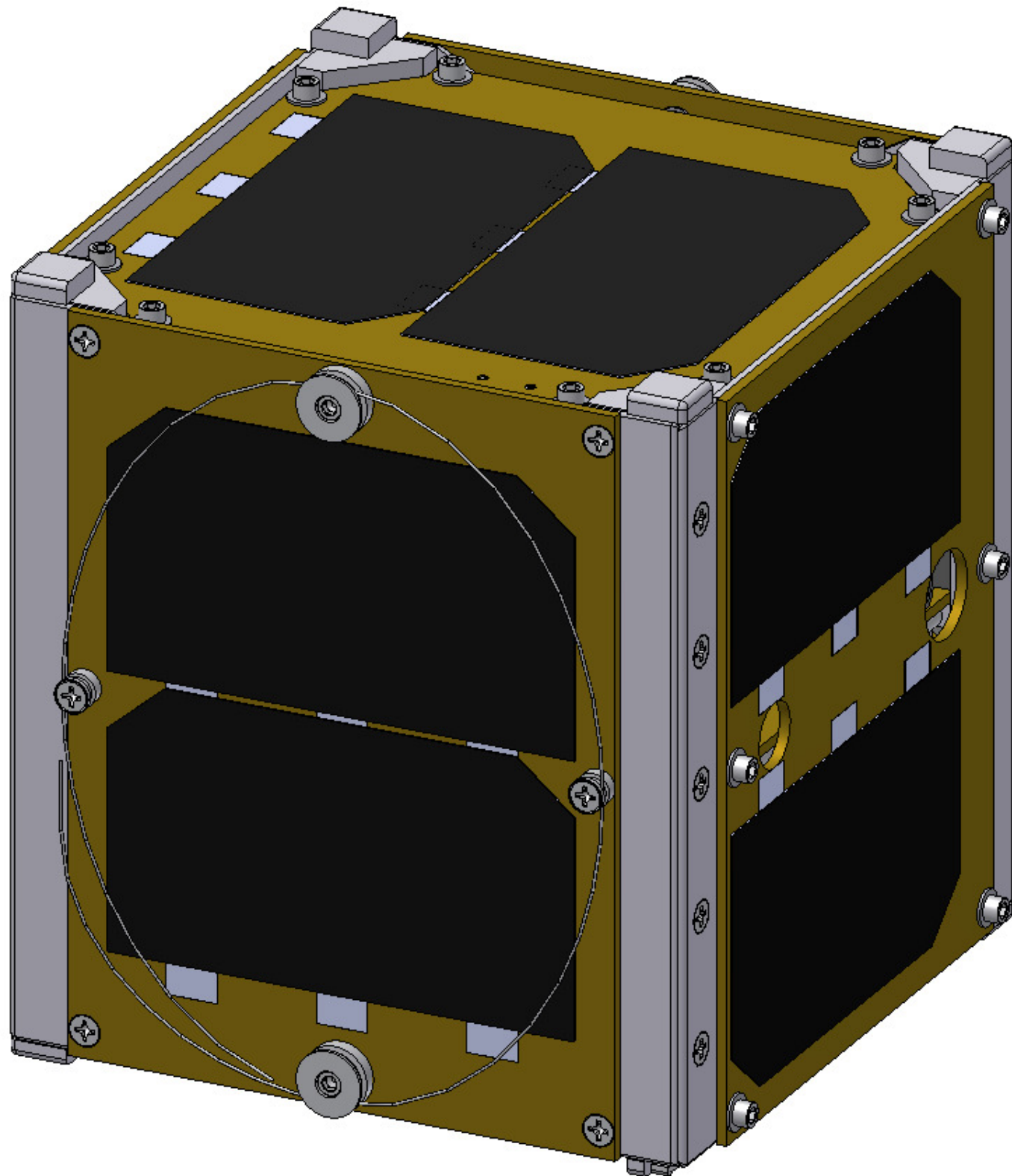


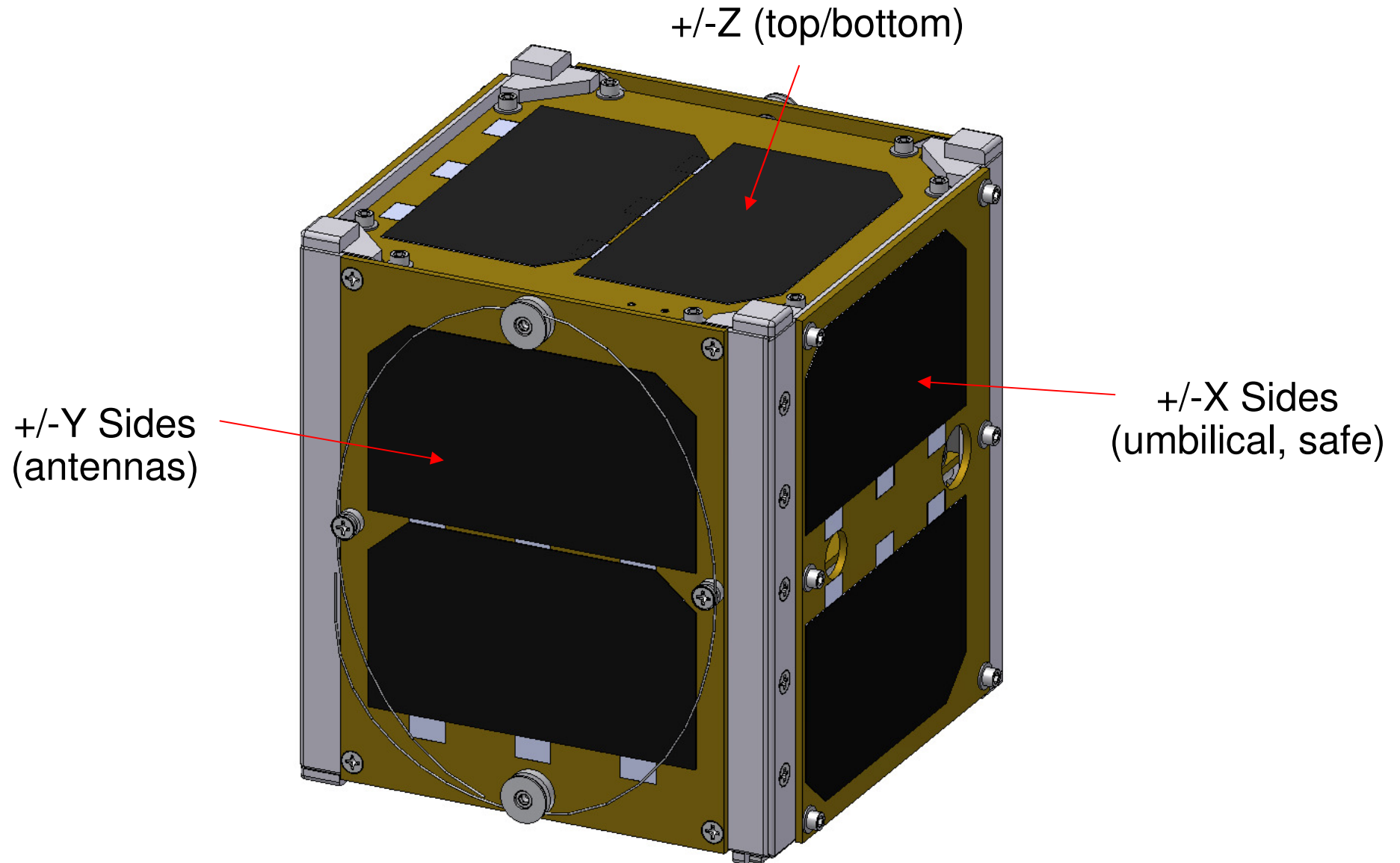
Fox 1 Mechanical Design

Robert Davis
KF4KSS

2012 AMSAT
Space Symposium



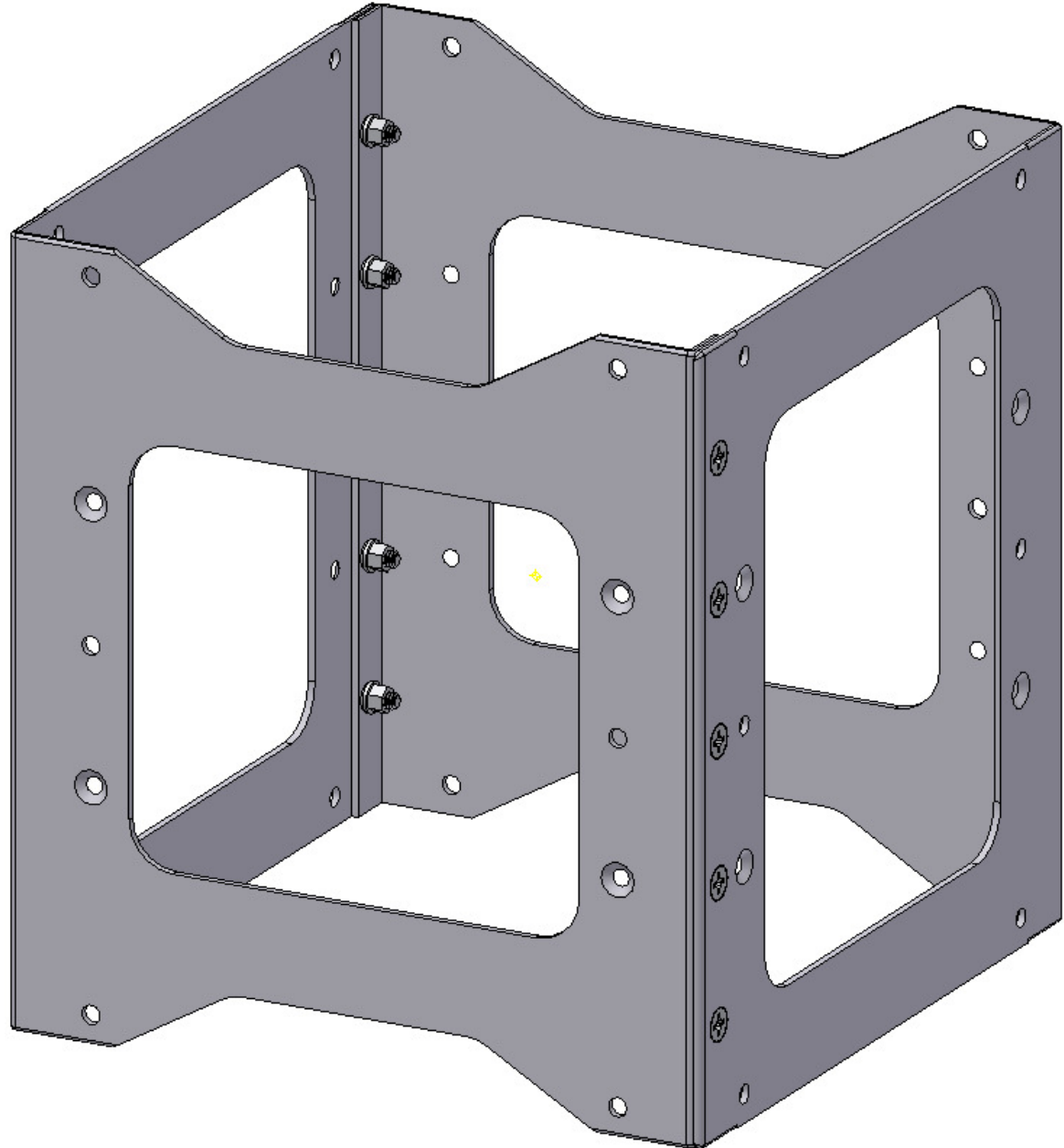
CLCs on Panels



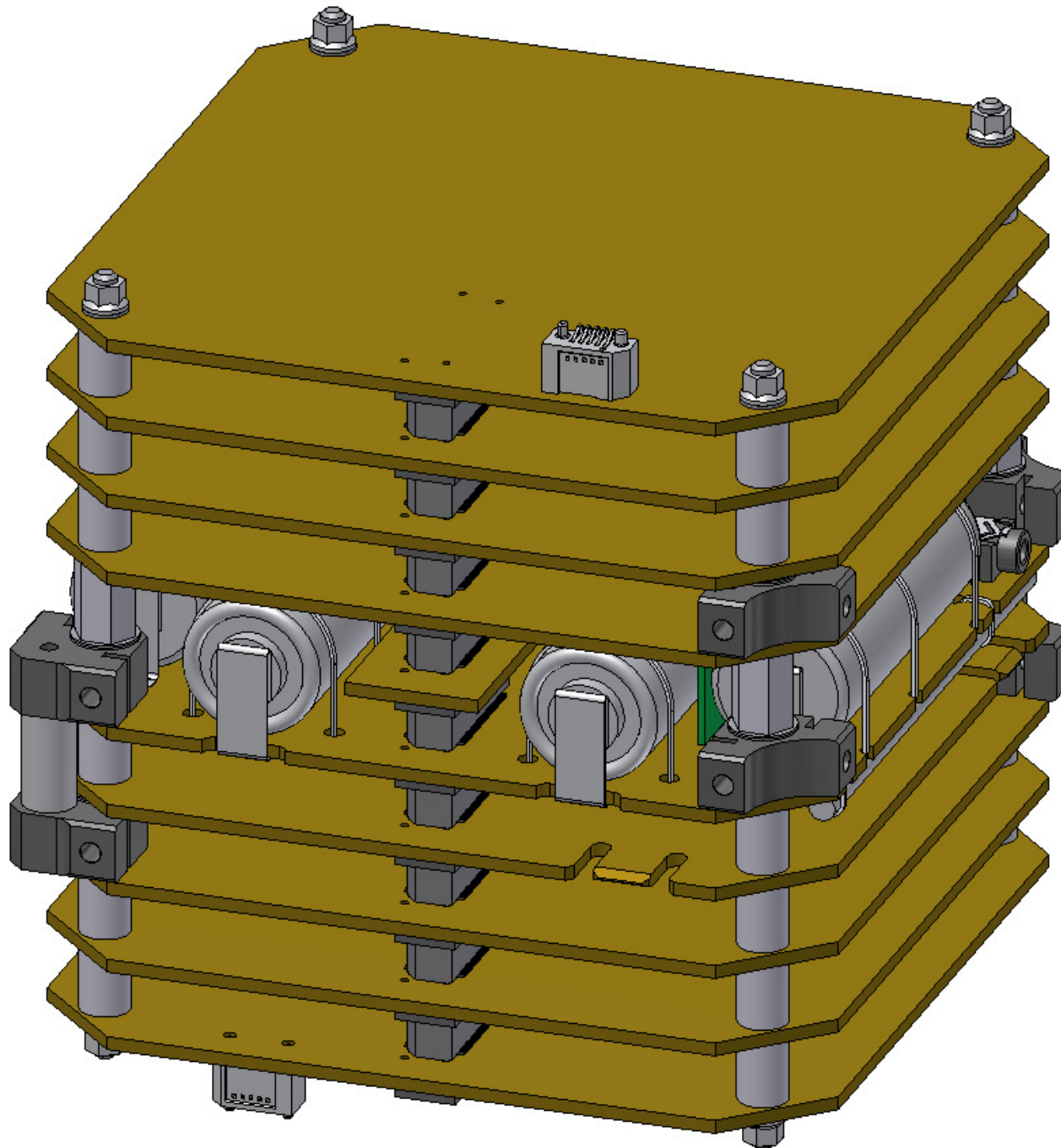
Each panel has two Spectrolab 26.62 cm² 28.3% UTJ with coverglass

Sheetmetal Walls

- 2-piece bent sheetmetal
- Fewer joints/fasteners
- Maximizes PCB volume
- 5052-H32 bendable with (almost) no radius
- Material waiver required with Cal Poly's CDS Rev 12
- No waiver required with KSC's LSP-REQ-317.01
- Tight tolerances of widths between PPOD Rails
- First prototype received from professional bender
- Need for second prototype anticipated



PCB Stack



Experiment #4

Experiment #3

Experiment #2

Experiment #1

(Battery #2)

Battery #1

PSU

IHU

Rx

Tx

Mass, CG, Spin Axis

- Mass limit is 1,330 g
- PCB Stack 824 g
- Walls 106 g
- Solar Panels 182 g
- Margin Avail 218 g
- On track for CG inside sphere radius 2cm
- $I_{xx} \approx I_{yy} \approx I_{zz}$
- No dominant spin axis from inertia matrix, but magnet is in Z axis
- Tumbles end-over-end
- Spin around Z axis encouraged by reflective/absorptive patches on solar panels

Config 6: centered, 3 edges

PCB & Clamps

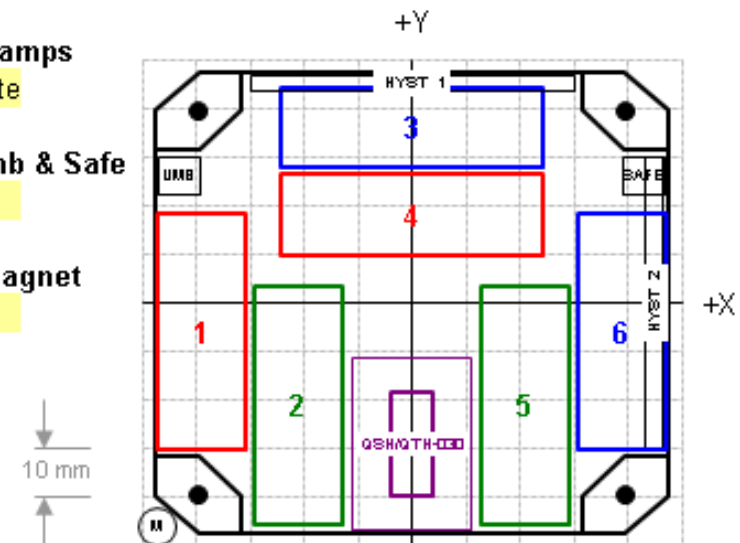
Moderate

Conn, Umb & Safe

Easy

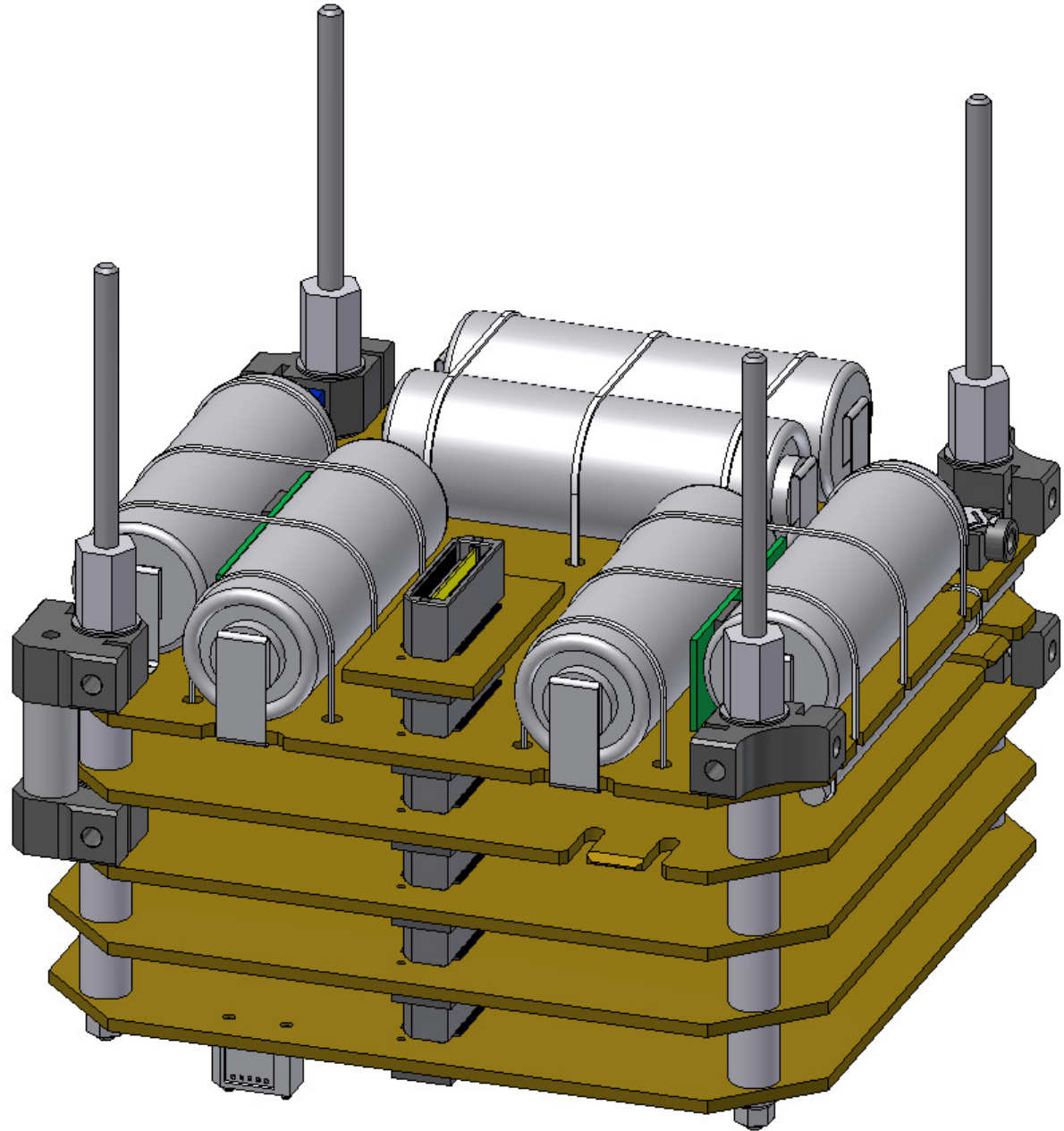
Rods & Magnet

Easy

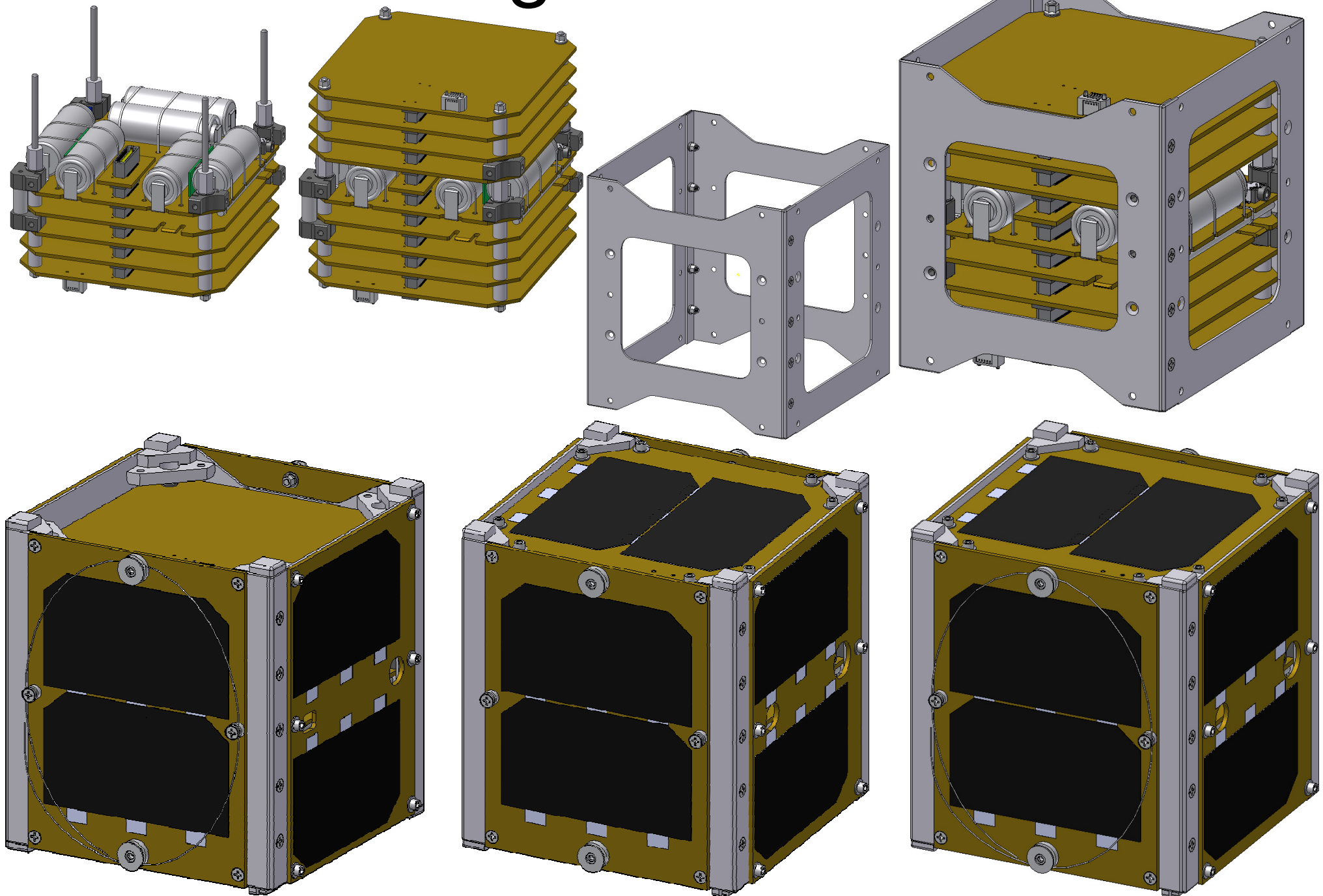


Avionics PCBs

- 10 PCBs “fill” the interior
- 95x95mm, standard 1/16” thick
- 8mm tall aluminum/copper spacers to match QSH/QTH bus connector
- Clearances:
 - 1.5 mm to side Aluminum
 - 2.5 mm to side solar panels
 - About 1 mm to rail extensions
 - About 6 mm to top/bottom solar panels
- Battery #2 has been shrunk and only holds bus connector
- Battery #1 has six “A” cells in pairs with thermostats, mini-USB, audio (safe), and hysteresis rods bottom side
- PSU has slots to act as edge cards into connectors of Side Solar Panels
- Magnet held in corner by pair of Delrin Mounts

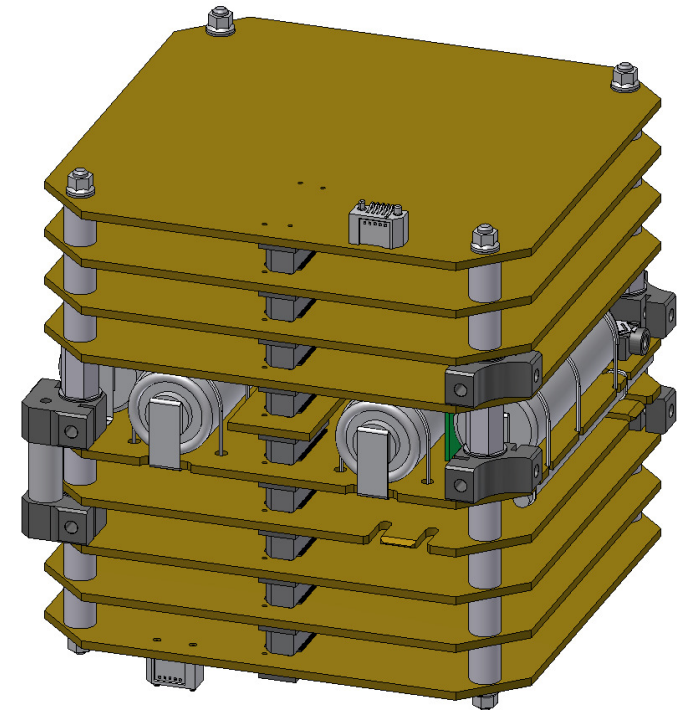
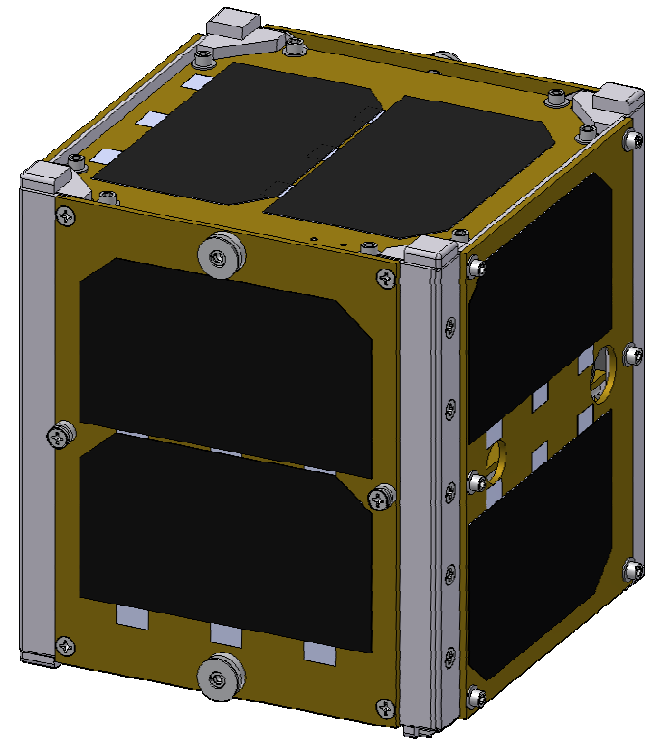


Integration Flow



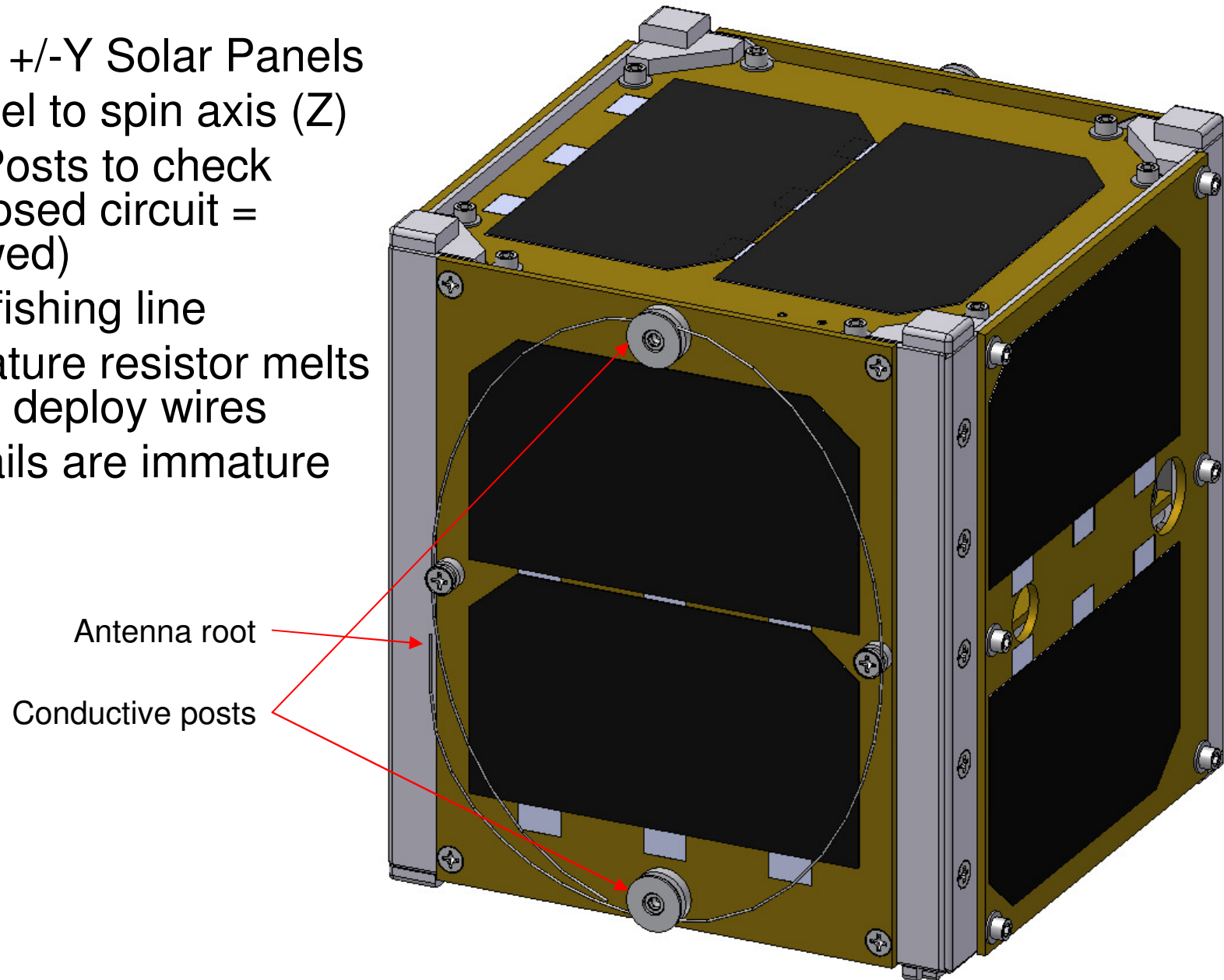
Thermal details

- Provided CAD physical model for creation of thermal analytical model
- Minimal opportunities for thermal to dictate materials, areas, or coatings of exterior
- Good bonding of side solar panels to structure
 - 6 screws and wide overlap of ground plane to aluminum
- Good bonding of PCBs with each other
 - Ground planes conduct to aluminum spacers
- Isolation of PCBs from structure
 - Conduction: Delrin with “long path” from PCBs to structure
 - Radiation: One-layer insulation on backside of +/-Z solar panels
 - Minimize heat leaks from connectors & coax
- Assist documenting of thermal inputs and results



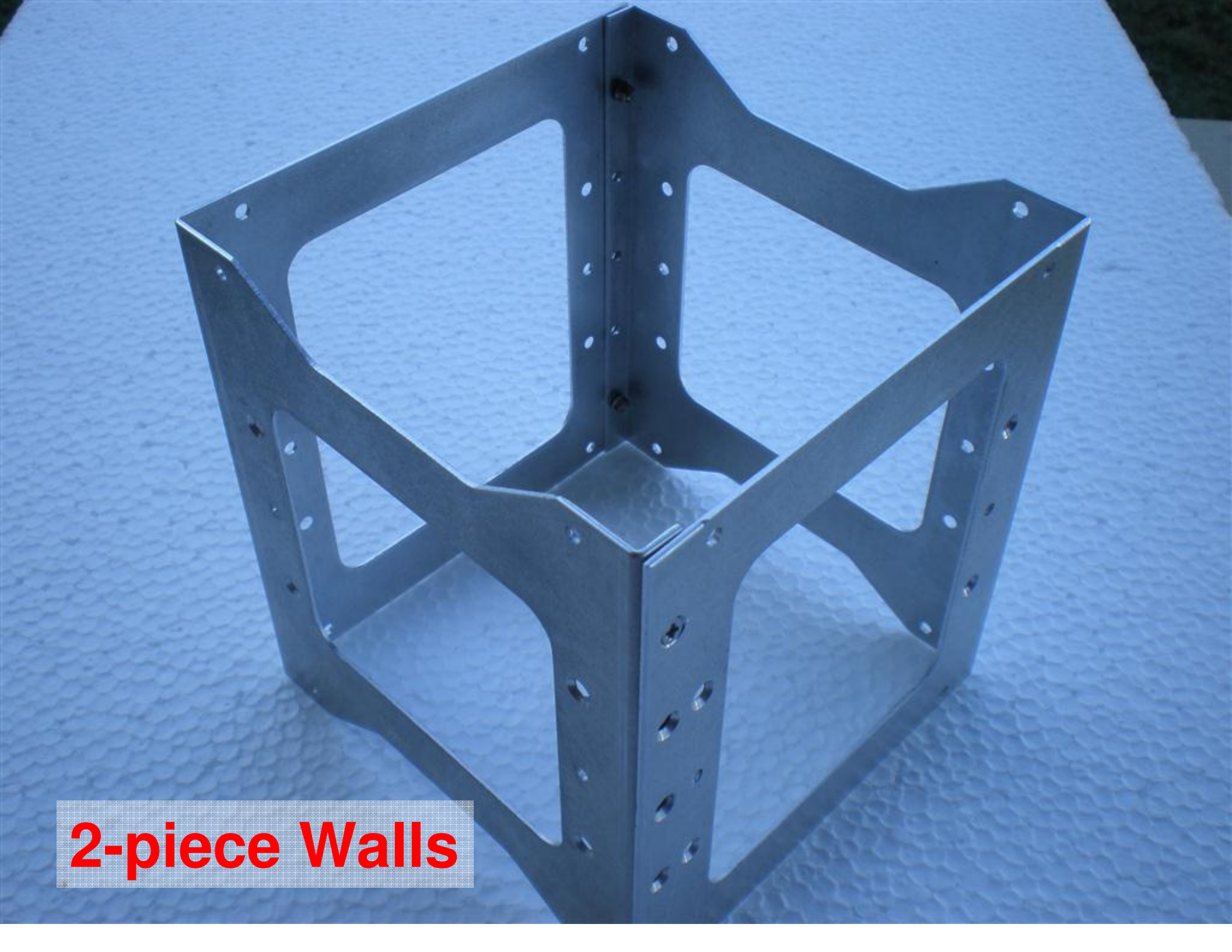
Antennas

- Wires coil on +/-Y Solar Panels
- Deploy parallel to spin axis (Z)
- Conductive Posts to check continuity (closed circuit = antenna stowed)
- Retained by fishing line
- High temperature resistor melts fishing line to deploy wires
- Physical details are immature



Prelim Checks

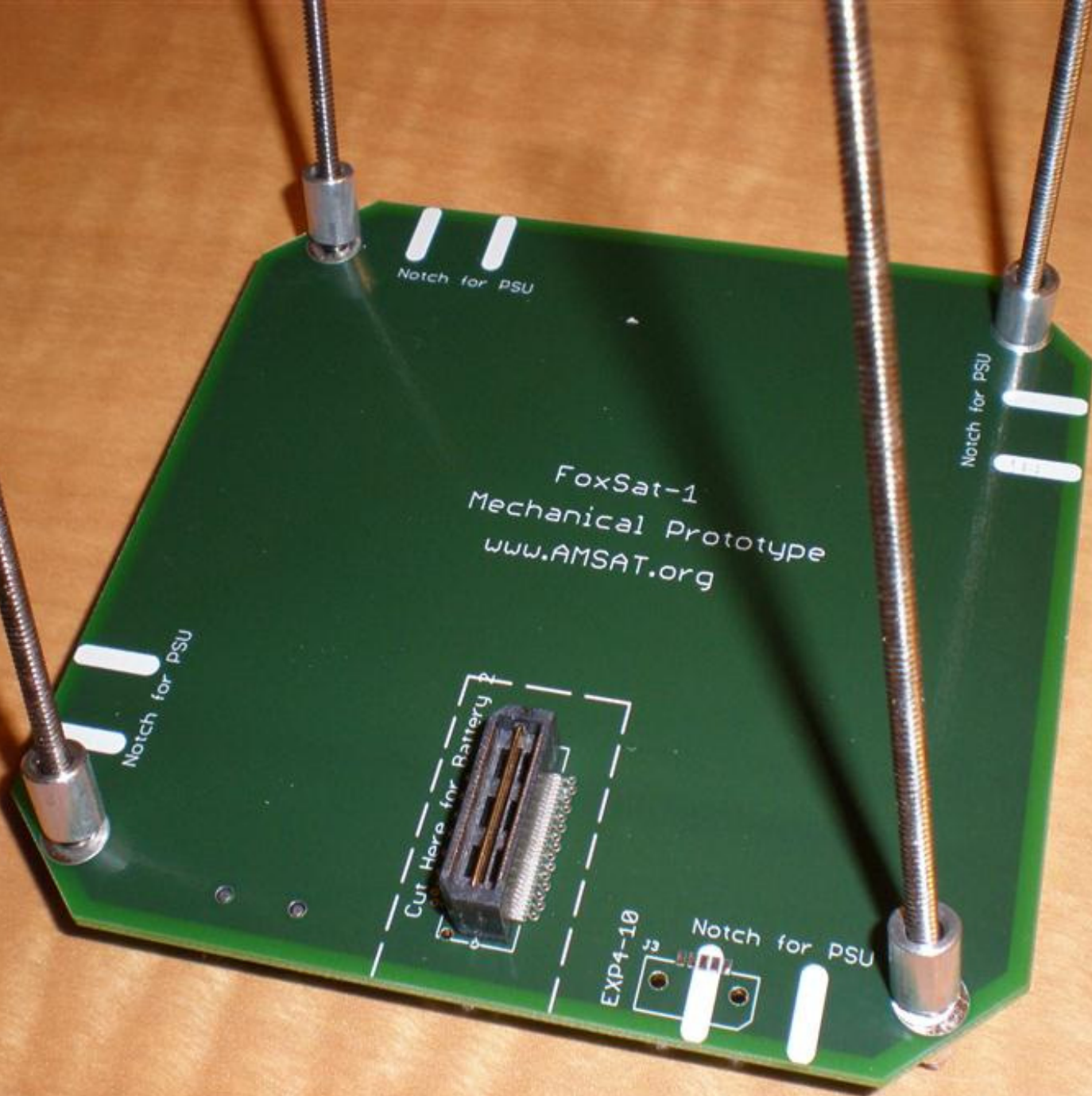
- With Cal Poly (2011)
 - Provided drawing of interpretation of envelope
 - Discussed sheetmetal plan
 - Provided CAD model screen capture of bent walls
- With NASA (2011)
 - Conversation about sheetmetal plan
- Building prototype (2012)
 - Incomplete at this time
 - A couple of months to capture all items



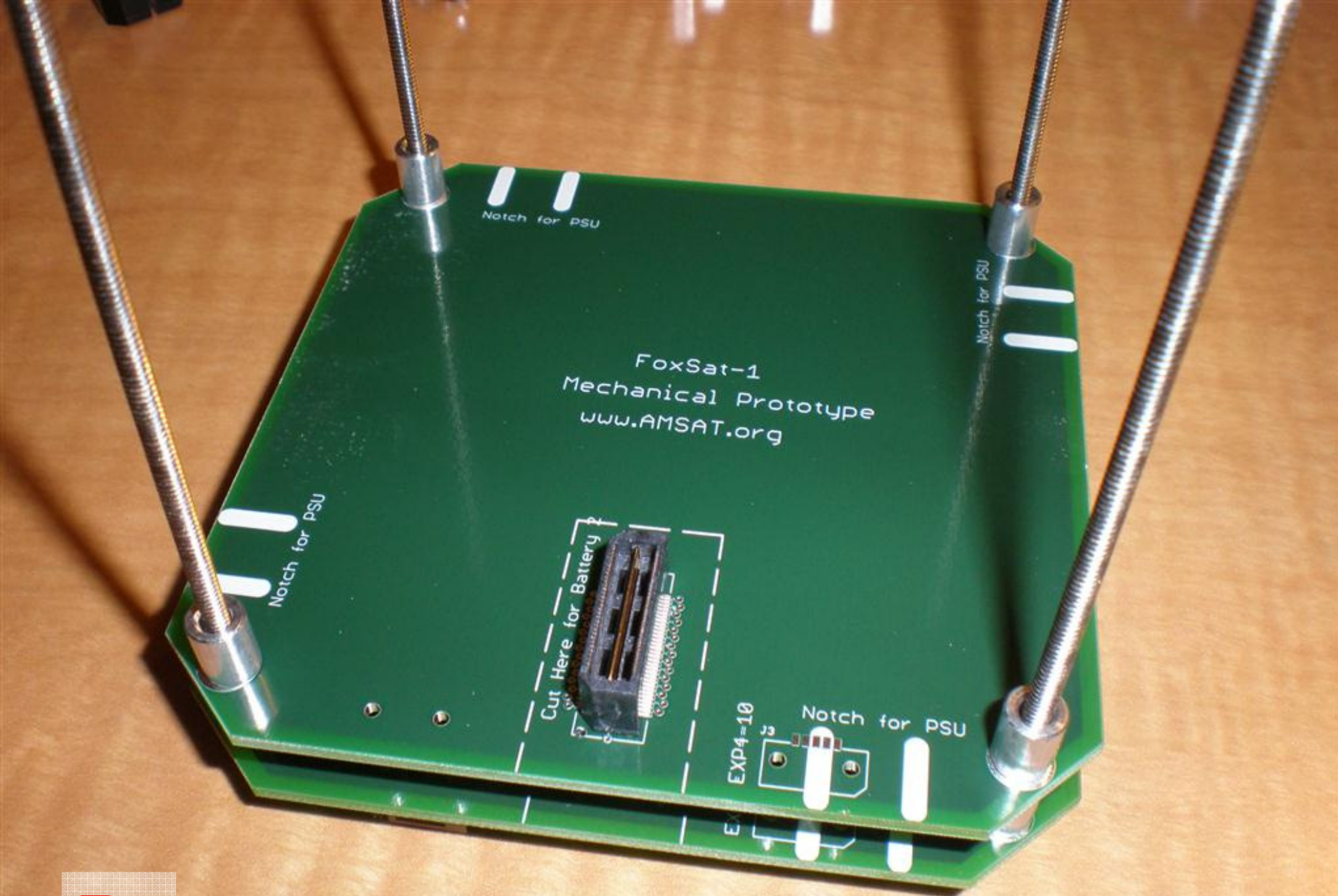
2-piece Walls

State of the art prototype cubesat assembly workstation courtesy of Holiday Inn - Orlando Int'l Airport

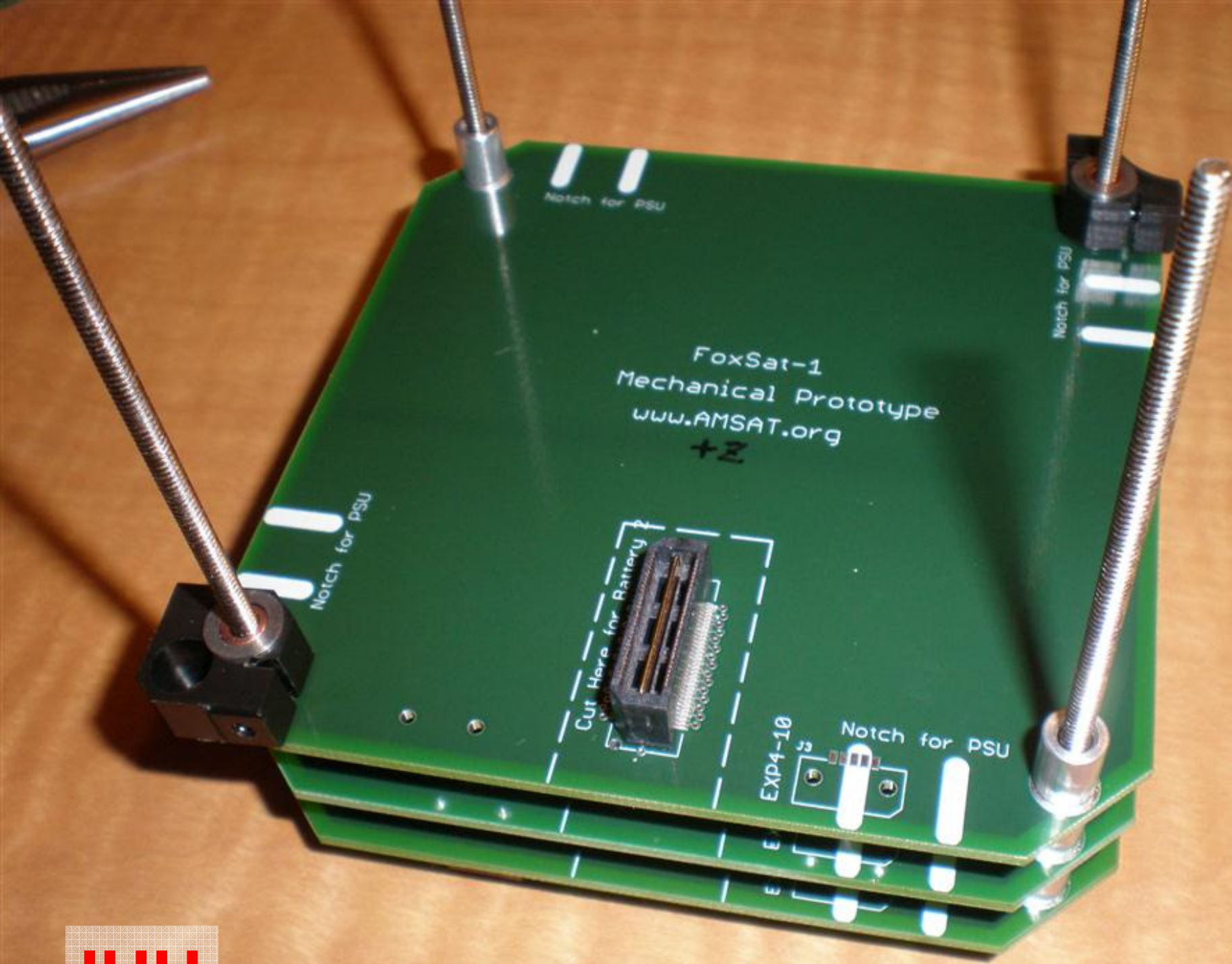




Tx



Rx



FoxSat-1
Mechanical Prototype
www.AMSAT.org

Notch for PSU

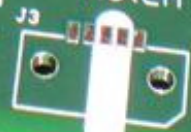
Notch for PSU

Notch for PSU

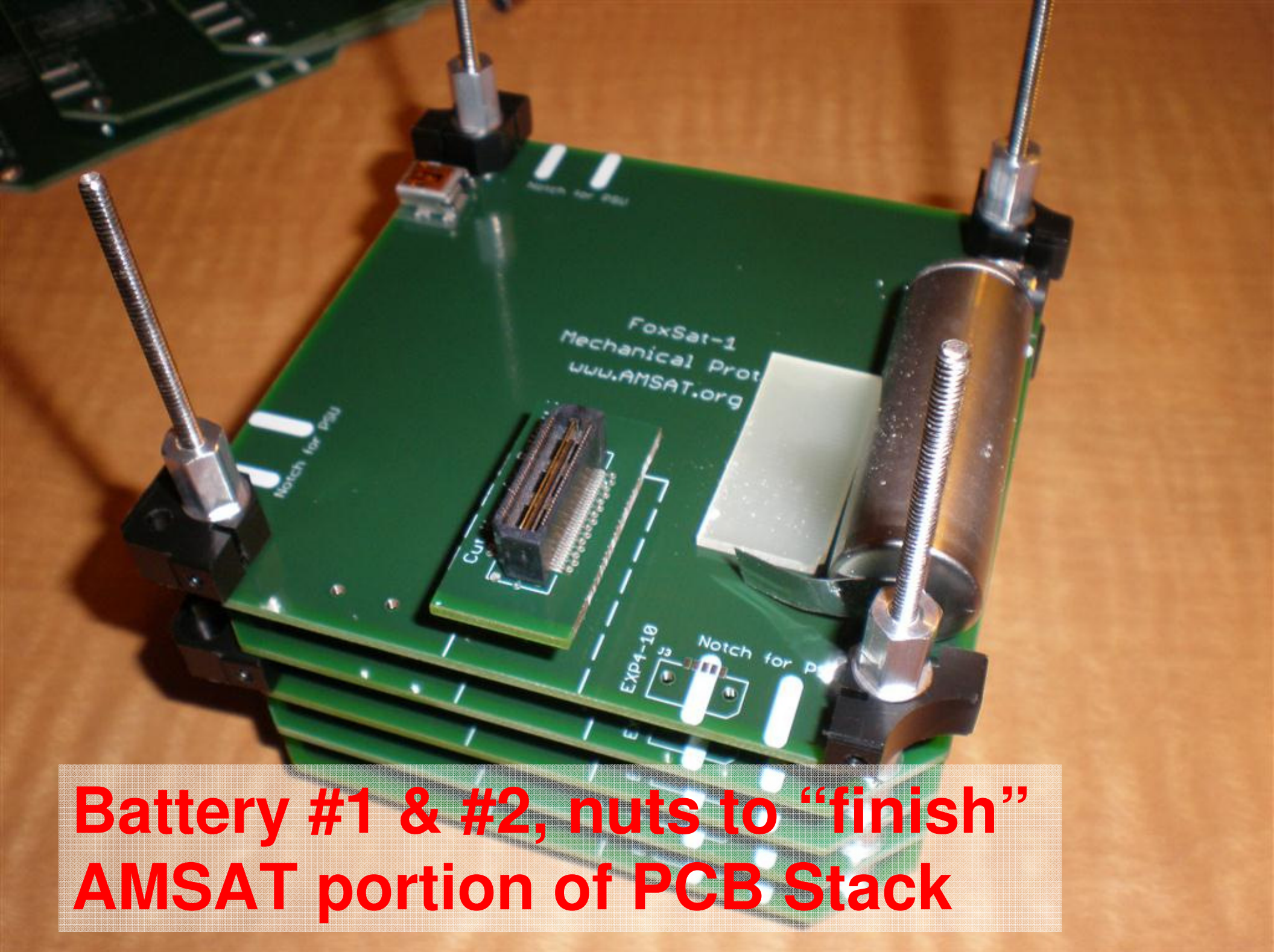
Cut Here for Battery

EXP4-10

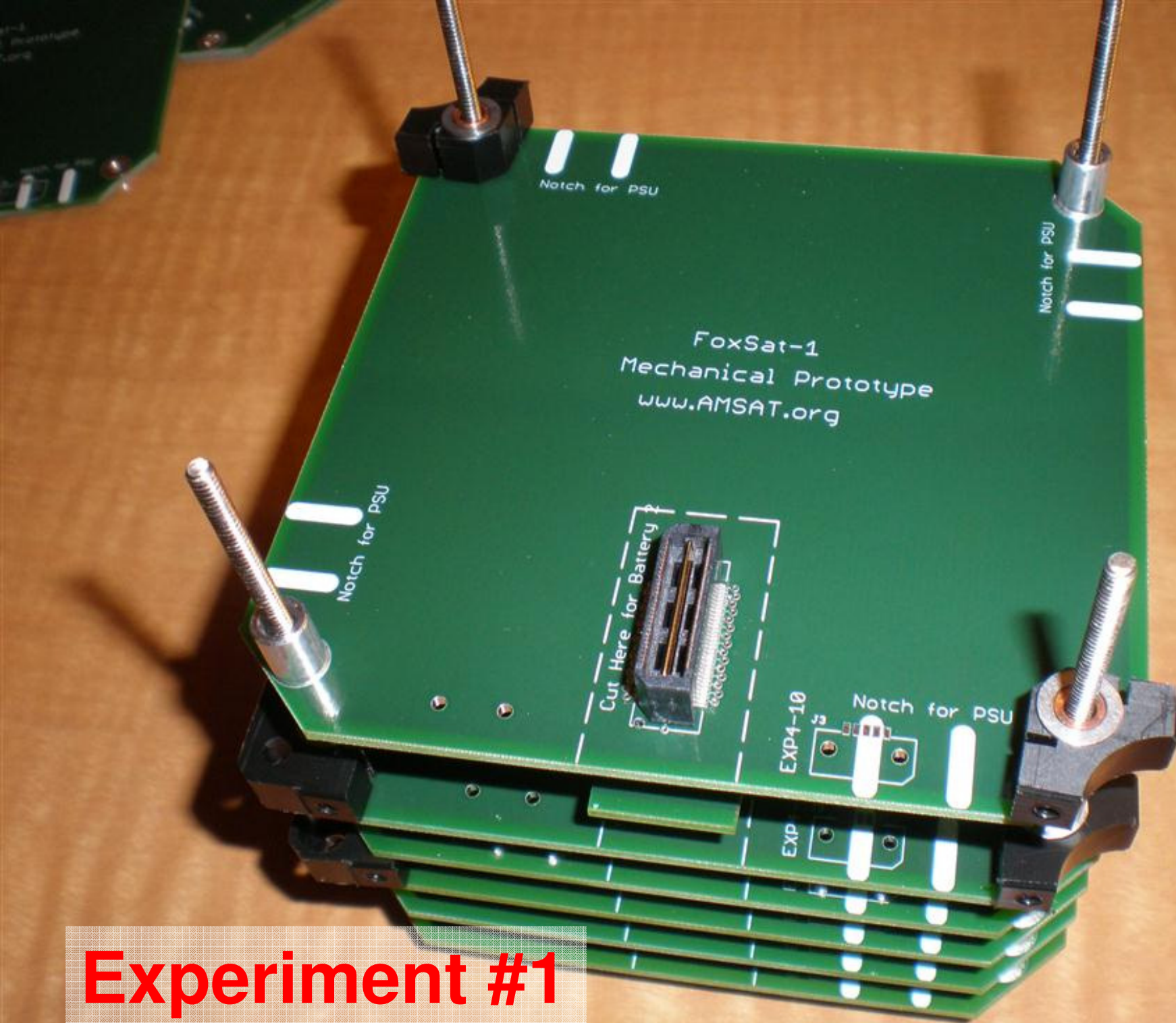
Notch for PSU



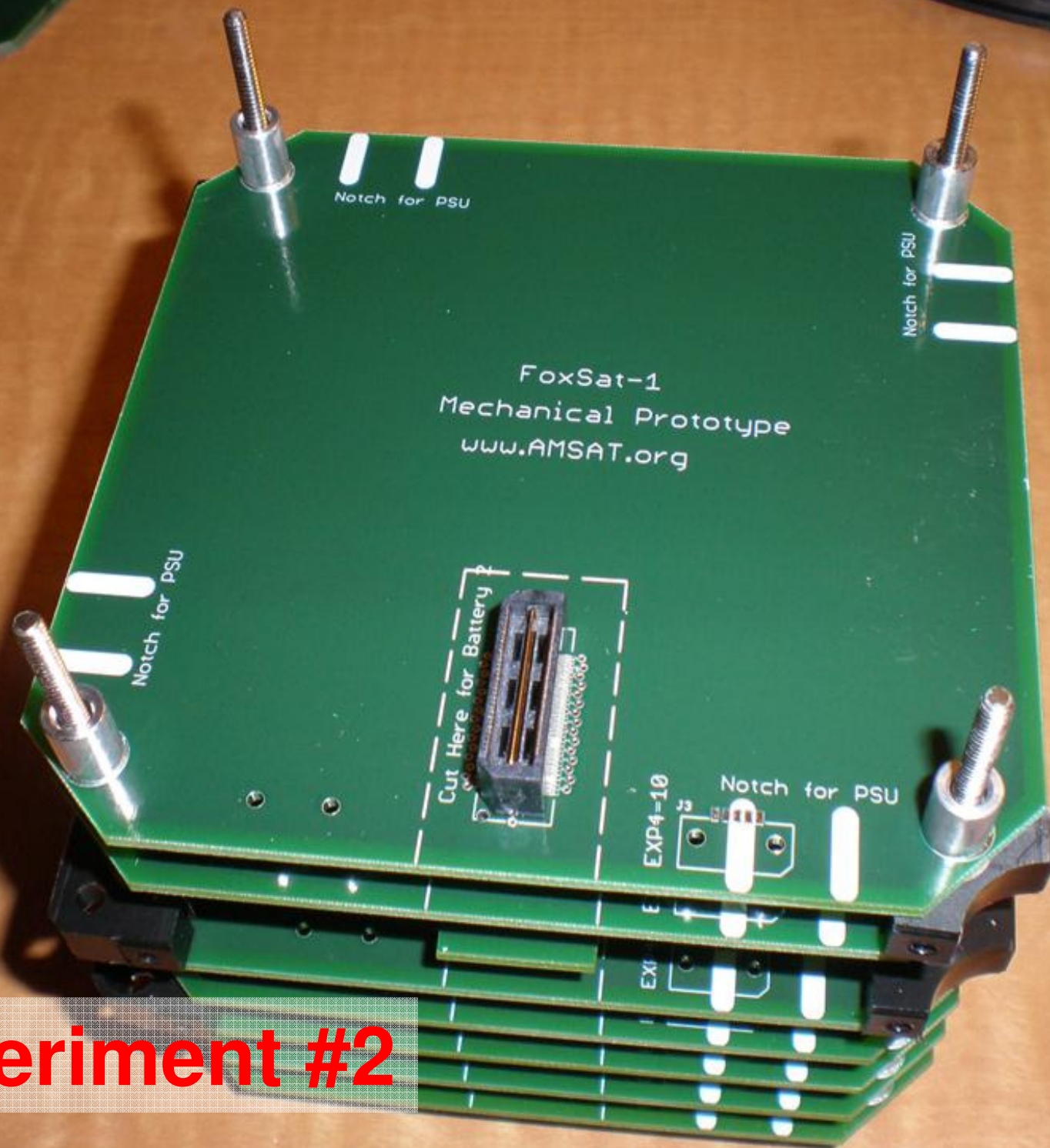
PSU



**Battery #1 & #2, nuts to “finish”
AMSAT portion of PCB Stack**

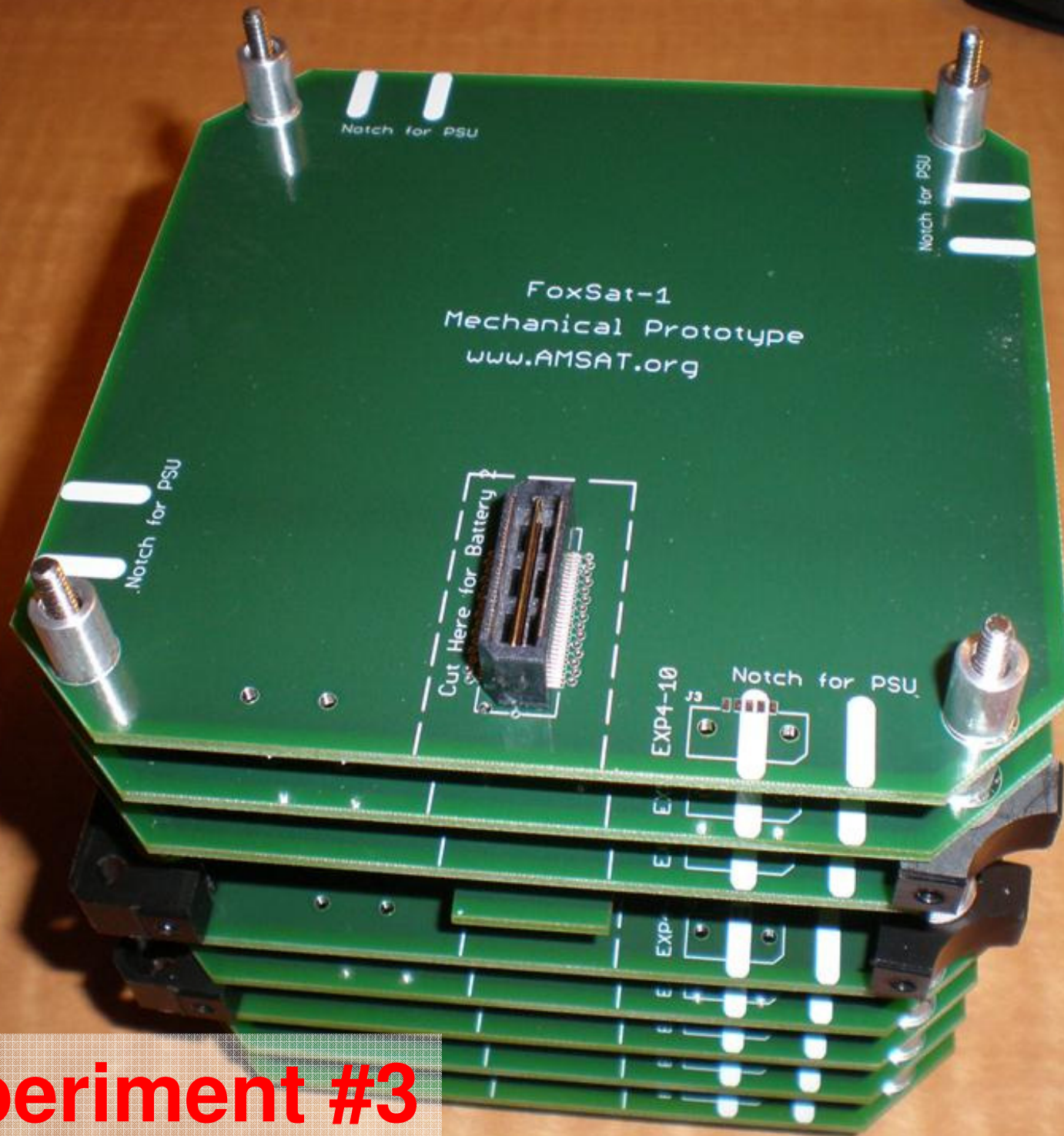


Experiment #1

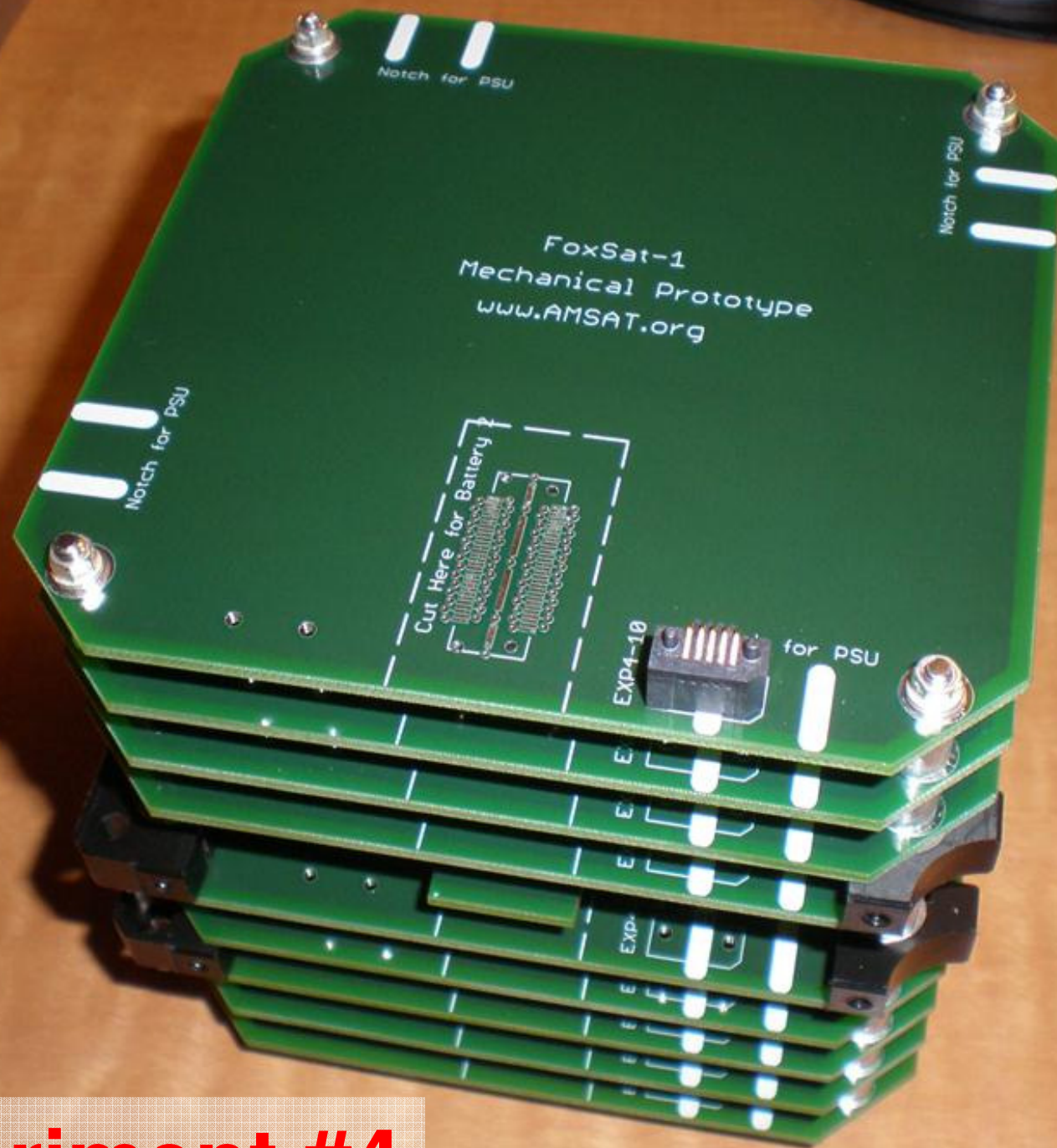


FoxSat-1
Mechanical Prototype
www.AMSAT.org

Experiment #2



Experiment #3



Experiment #4



PCB Stack in Walls, & +/-X Solar Panels



View of bus connectors

Near-term Proto

- 1st Prototype to include (couple months)
 - PSU edges for Solar Panel edge card connectors (no pads)
 - Battery #1 to include (no pads) wrapped batteries, daughter boards with SMD thermostat, hysteresis rods, mini-USB, 2.5mm audio jack (safe), battery in corner between Delrin Mounts
 - +/-Y Solar Panels
 - Rail Ends and +/-Z Solar Panels
- 2nd Prototype fit check in PPOD (early 2013)
 - Walls will be properly anodized at Rail
 - Connector functional PSU & Battery #1 with batteries, rods & lacing cord

Lessons Learned Already

- Must be more explicit on steps for sheetmetal to avoid clamp marring, orbital sanding, rough edges, countersunk holes recess screws too deep
- Sheetmetal bends appear to meet tight tolerances
- Fixtures needed for Walls assembly, PCB stacking
- Standoffs/Delrin between PCBs work well
- Very pleased with prototype PCB Stack and insertion into Walls
- Batteries too thick for allotted height

The real skinny

- Batteries, after flexible heater, kapton tape and lacing cord interfere with Experiment #1
 - Likely action: increase thickness of Battery #2 from 0.062" to 0.093"
 - Cascades to
 - bolt pattern in Walls to match location of Delrin Mounts
 - gap from end of PCB Stack to +/-Z Solar Panels
(Connector is 6mm tall. If PCB Stack is taller by 0.031" then +Z solar must also be raised)
- Antenna needs a lot of practical design

Mechanical Team

Bob Davis KF4KSS@amsat.org

New volunteers with Fox:

Corey Abate	KD8RQI	Layout of solar panel circuit boards
Andy Abken	KN6ZA	Machining
Steve Christie		Assisting design
Dan Passaro	AK4PX	Leads sheetmetal
Dan Welch	W6DFW	Machining